CHAPTER 2

GENERAL ENVIRONMENTAL CONSIDERATIONS

2-1. Study Requirements.

a. General. Both new projects and operation and maintenance activities must be consistent with national environmental policies. In general, these policies require creation and maintenance of conditions under which human activities and natural environments can exist in productive harmony including preservation of historic and archeological resources. Deep-draft navigation projects are documented by a series of studies, each more specific than the previous one. The series of reports produced for a given type of project varies by Corps Division and by the date of the project (due to changing regulations). However, in general, an initial evaluation (or reconnaissance) report and a feasibility (or survey) report are prepared prior to Congressional project authorization. (Refer to ER 1105-2-10 for a description of this process.) Environmental studies are included in an overall framework of engineering, economic, and other types of analyses (ER 1105-2-50).

b. Statutes and Regulations. Compliance with Federal statutes, executive guidelines, and Corps regulations often requires studies of existing environmental conditions and projections of conditions likely to occur in the future with and without various activities. Table 2-1 lists the major environmental statutes and regulations that are currently applicable to Corps deep-draft navigation projects. Three statutes that have a major impact on the planning and operation of deep-draft navigation projects are: The National Environmental Policy Act, The Clean Water Act, and The Marine Protection, Research and Sanctuaries Act.

(1) National Environmental Policy Act (NEPA). NEPA is the Federal statute that established national policy for the protection of the environment and set goals to be achieved along with the means to carry out these goals. For deep-draft navigation projects, including operation and maintenance, where significant effects upon the human environment are expected, an Environmental Impact Statement (EIS), in accordance with US Environmental Protection Agency (EPA) implementing regulations for NEPA (40 CFR 220-229), will normally be required. An Environmental Assessment (EA), in lieu of an EIS, may be a sufficient means to evaluate the impacts of certain navigation-related activities which would have no significant impact on the environment. (ER 200-2-2 provides detailed guidance.)

(2) Clean Water Act. Section 404 of the Clean Water Act governs the discharge of dredged or fill material into waters of the United States. The evaluation of the effects of discharge of dredged or fill material should include consideration of the guidelines developed by EPA (40 CFR 230) in accordance with the requirements of Section 404(b)(1). These requirements include an evaluation of disposal alternatives; a determination that the proposed discharge will not result in an unacceptable degradation of the physical, biological, and chemical integrity of the waters of the United States; and consideration of those factors in Sections 403(c)(1) and 404(c). See paragraph 5-6 of this manual and 33 CFR 209.145 for additional details.

Table 2-1. Environmental Protection Statutes and Other Environmental Requirements

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Federal Statutes

Clean Air Act, as amended, 42 U.S.C. 7401, et seq.

Clean Water Act, as amended (Federal Water Pollution Control Act), 33 U.S.C. 1344, et seq.

Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1451, et seq.

Deep Water Port Act of 1974, as amended, 33 U.S.C. 1501, et seq.

Endangered Species Act, as amended, 16 U.S.C. 1531, et seq.

Estuary Protection Act, 16 U.S.C. 1221, et seq.

Federal Water Project Recreation Act, as amended, 16 U.S.C. 668aa-668ee, et seq.

Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661, et seq.

Historic Site Act of 1935, as amended, 16 U.S.C. 461, et seq.

Land and Water Conservation Fund Act, as amended, 16 U.S.C. 4601-4601-11, et seq.

Marine Protection, Research and Sanctuaries Act of 1972, 33 U.S.C. 1401, et seq.

National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321, et seq.

National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470, et seq.

Preservation of Historic and Archaeological Data Act of 1974, as amended, 16 U.S.C. 469, et seq.

River and Harbor Act, 3 March 1899, 30 stat. 1151, 33 U.S.C. 401 and 403, and 30 stat. 1152, 33 U.S.C. 407, et seq.

Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.

Wild and Scenic Rivers Act of 1968, as amended, 16 U.S.C. 1271, et seq.

Executive Orders, Memoranda, etc.

Protection and Enhancement of Cultural Environment (E.O. 11593)

(Continued)

Table 2-1 (Continued)

Executive Orders, Memoranda, etc.

Floodplain Management (E.O. 11988)

Protection of Wetlands (E.O. 11990)

Protection and Enhancement of Environmental Quality (E.O. 11991)

Environmental Effects Abroad of Major Federal Actions (E.O. 12114)

Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum, 11 Aug 80)

Interagency Consultation to Avoid or Mitigate Adverse Effects on Rivers in the Nationwide Inventory (CEQ Memorandum, 11 Aug 80)

Guidance on Applying Section 404(r) of the Clean Water Act to Federal Projects Which Involve the Discharge of Dredged or Fill Materials into Waters of the U. S. Including Wetlands (CEQ Memorandum, 17 Nov 80)

Agency Regulations

Corps of Engineers

Policy and Procedures for Implementing NEPA	(ER 200-2-2)
Planning Programs	(ER 1105-2-10)
Project Planning	(EP 1105-2-15)
General Planning Principles	(ER 1105-2-30)
Environmental Resources	(ER 1105 -2-50)
Recreation-Resource Management of Civil Works Water Resource Projects (Changes 1 thru 4, 28 May 71) (Under Revision, DAEN-CWO-R)	(ER 1130-2-400)
Lake Shore Management at Civil Works Projects	(ER 1130-2-406)
Corps of Engineers Participation in Improvements for Environmental Quality, 30 Apr 80	(ER 1165-2-28)

(Continued)

Table 2-1. (Concluded)

Agency Regulations (Continued)	
US Environmental Protection Agency	
Ocean Dumping Regulations and Criteria	(40 CFR 220-229)
Guidelines for Specification of Disposal Sites for Dredged or Fill Material	(40 CFR 230)
Council on Environmental Quality	(33 CFR 209.145)
Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act of 1969	(40 CFR 1500-1508)

(3) The Marine Protection, Research and Sanctuaries Act (MPRSA). The MPRSA governs the transport of dredged material for the purpose of ocean disposal. Title I of the MPRSA, which is the Act's primary regulatory section, authorizes the Secretary of the Army acting through the Corps (Section 103) to establish ocean disposal permit programs for dredged materials. In addition, Section 103(e) requires that Federal projects involving ocean disposal of dredged material shall meet the same requirements as developed for permits. Title I also requires EPA to establish criteria (40 CFR 220-229), based on those factors listed in Section 102(a), that provide the basis for evaluating permit actions and Federal projects. Further, Section 102(c) of Title I authorizes EPA to designate recommended ocean disposal sites and/or times for dumping of nondredged and dredged material. In the evaluation of Federal projects, major consideration must be given to assessing the effects of ocean disposal of dredged material on human health, welfare, or amenities, or the marine environmental, ecological, or economic potentialities. As part of this evaluation, consideration must be given to utilizing, to the extent feasible, ocean disposal sites designated by the EPA. (Refer to paragraphs 5-2 and 5-3 of this manual and 33 CFR 209.145 for additional details.)

c. Environmental Study Management. At each stage of a project, efforts should be made to identify key environmental concerns and corresponding future information needs. Forecasting of data needs is necessary in order to schedule adequate time and funding for field data collection, physical or numerical modeling, etc. Scheduling work by others should allow time and funds for administrative procedures such as contractor selection, contract management, review procedures, and potential delays.

(1) Critical issues. Time and money constraints preclude detailed investigations and data collection for every area of interest; therefore, the most critical issues should be identified. It is essential that the number of factors assessed be adequate to fully account for all significant effects. However, increases in the numbers of factors will increase the time, funds, and expertise required for study. Therefore, a proper balance between adequate analysis and study resources must be achieved. Criteria for determining the importance of an issue include, but are not limited to, statutory requirements, executive orders, agency policies and goals, and public interest.

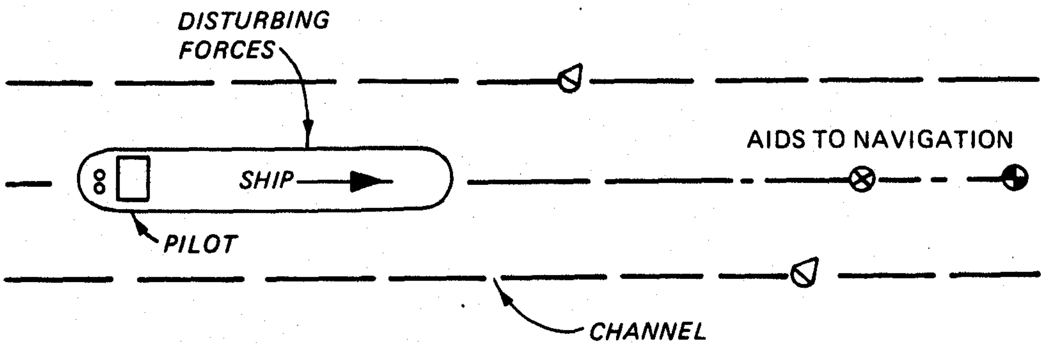
(2) Environmental data. Methodology for environmental data collection is discussed in greater detail in Chapter 5 of this manual. Each investigation must be designed with well-defined, detailed objectives prior to data collection. Investigation design should include a rationale for hypotheses to be tested, variable selection, sampling locations and frequencies, and data storage and analysis.

(a) Environmental studies during the preliminary stages of project development should emphasize identification of resources, development of an evaluation framework, and collection of readily available information for all potential alternatives. Resources likely to be impacted are investigated, and further information needs are identified.

(b) Detailed analysis normally occurs after two or three specific alternatives have been selected for further study. Major emphasis of environmental studies in the detailed assessment stage should be directed toward identifying, describing, and appraising individual effects and evaluating the net effects of each alternative. Both positive and negative environmental effects should be characterized in adequate detail so they can be used along with the economic and technical analyses to compare alternatives.

2-2. Hydraulic Design Aspects.

a. General. This section has been included to provide the user with an overview of hydraulic considerations for deep-draft projects. The user should refer to EM 1110-2-1613 for more detailed guidance on hydraulic design for deep-draft projects. The following factors are major considerations in the hydraulic design of deep-draft waterways: the amount, size, and type of traffic that will be using the waterway; commodities moved; safety; efficiency; reliability; and cost. Safe use of the project should receive primary consideration before the project is optimized with respect to cost. Safety will depend upon vessel size and maneuverability, size and type of channel, effects of currents and wind, placement and condition of navigational aids, and experience and judgment of the pilots (Figure 2-1).



- PILOTING ASPECTS
  SKILL, DILIGENCE, TRAINING, KNOWLEDGE
- NAVIGATION/INFORMATION AIDS
  ACCURACY, RADAR AND DECCA, METEO/HYDRO
- ENVIRONMENTAL FACTORS
  WIND, WAVE, CURRENT, VISIBILITY, TRAFFIC
- CHANNEL PROPERTIES
  TYPE, LAYOUT, CRITICAL MANEUVERS

Figure 2-1. Factors influencing channel dimension

b. Channel Design Data Requirements. Data to be collected prior to design of navigation channels include maximum and minimum water levels and frequency, duration, and amplitude of water-level fluctuations. Tidal data are required to determine the appropriate water-level data for waterways influenced by tides. Estimates of wind, waves, and currents are needed to determine their effects on vessel motions and controllability. Estimates of the rates of sediment erosion and deposition, extent and characteristics of salinity intrusion, and flushing characteristics are also usually needed.

c. Design Vessel. Before initiating design of a navigation channel, a design vessel must be selected. The projected vessel fleet over the economic life of the project will be an aid in selecting characteristics of the design vessel. The amount of traffic will determine if one-way or two-way traffic should be provided. Layouts of the various channel dimensions and alignment plans to accommodate the design vessel should be evaluated on the basis of tonnage, trip time, safety, environmental and social impacts, and construction and maintenance costs.

d. Channel Alignment. After the design vessel has been selected, the channel alignment and dimensions must be optimized. The alignment of a navigation channel is usually designed to follow the course of the deepest channel in a river or estuary. This is done in order to minimize initial and maintenance dredging. Bends in the alignment should be minimized as much as possible, and where gradual bends are not practical, cutoffs should be considered. Channel alignment studies should consist of selecting several alternate routes and estimating construction and maintenance costs for each. An optimum channel alignment is determined according to a comparison of annual project costs and benefits, assuming there are no overriding cultural or environmental constraints.

e. Channel Depth. Channels of limited depth can affect ship maneuverability because of the turbulent flow pattern produced. In shallow water, vessels become harder to handle and require large rudder angles to maneuver. Shallow-water operations require greater power and use more fuel than operations in deep water. The design channel depth should be adequate to accommodate the deepest draft vessel expected to use the waterway, although if the deepest draft vessel rarely uses the channel, it may be economic to expect the vessel to transit only at higher water stages. The design depth should be selected after comparing the cost of vessel delays, operation, and light loading with the construction and maintenance cost involved as well as the associated net economic benefits of each size of channel considered in the project investigation. The required depth is the total of the following factors: design vessel loaded draft, squat, sinkage in fresh water, effect of trim and wave action, and safety efficiency clearance. Figure 2-2 depicts depth determination factors. Refer to EM 1110-2-1613 for detailed design information.

f. Channel Width. Channel widths should be designed to provide for the safe and efficient movement of the vessels expected to use the channel. The minimum channel width will depend on the size and maneuverability of the vessels, channel shape and alignment, traffic congestion, wind, waves, currents, visibility, quality and spacing of navigation aids, and whether one-way or two-way traffic is allowed. Guidelines for estimating approximate channel width are shown in EM 1110-2-1613. Channel widths have to provide for the width of the maneuvering lane, clearances between vessels when passing, and bank clearances. Elements that should be included in computing total channel width are shown in Figure 2-3. The maneuvering lane is that portion of the channel width within which the vessel might deviate from a straight line without encroaching on the safe bank clearance or on the path of another vessel. Maneuvering lanes must be separated to provide safety clearance for channels designed for two-way traffic in order to avoid interference and danger of collision. Bank clearance is required to reduce or eliminate both the danger of hitting the bank or grounding and the effect of bank suction on the controllability of the vessel. A wider maneuvering lane will be required in bends since the path of a vessel making a turn is wider than its path in a straight reach. The width of the

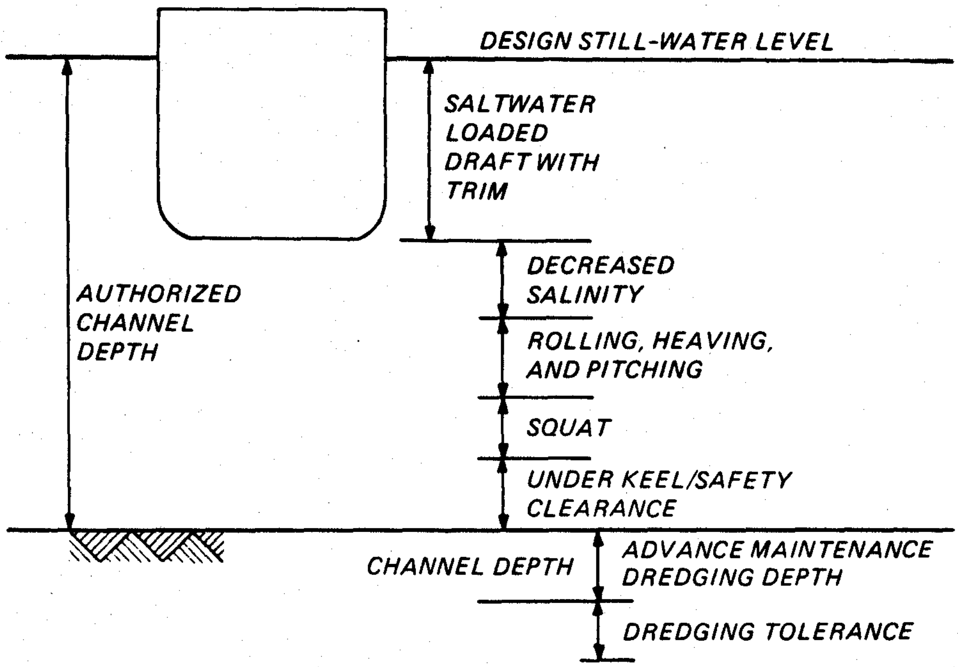


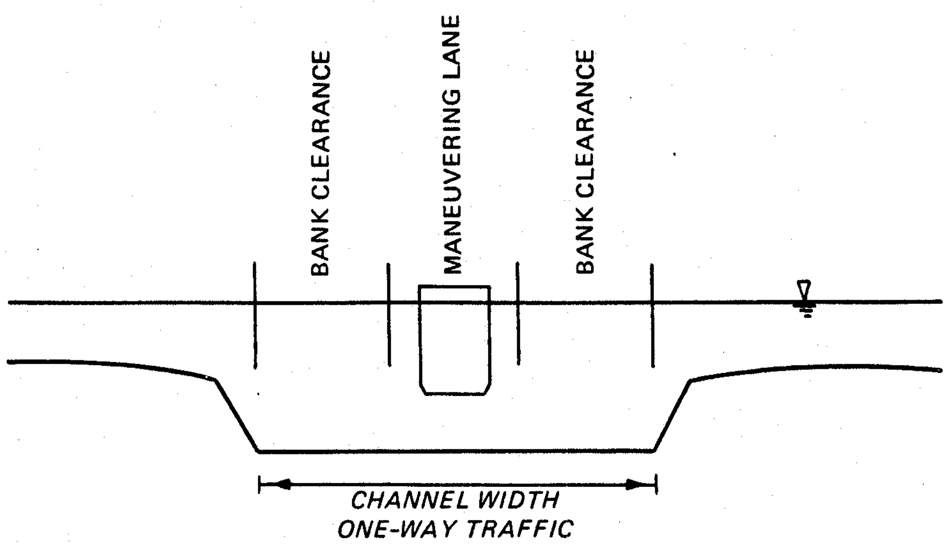
Figure 2-2. Factors affecting required channel depth

path will depend on the amount of turn, speed and maneuverability of the vessel, length and beam of the vessel, and effects of waves and current.

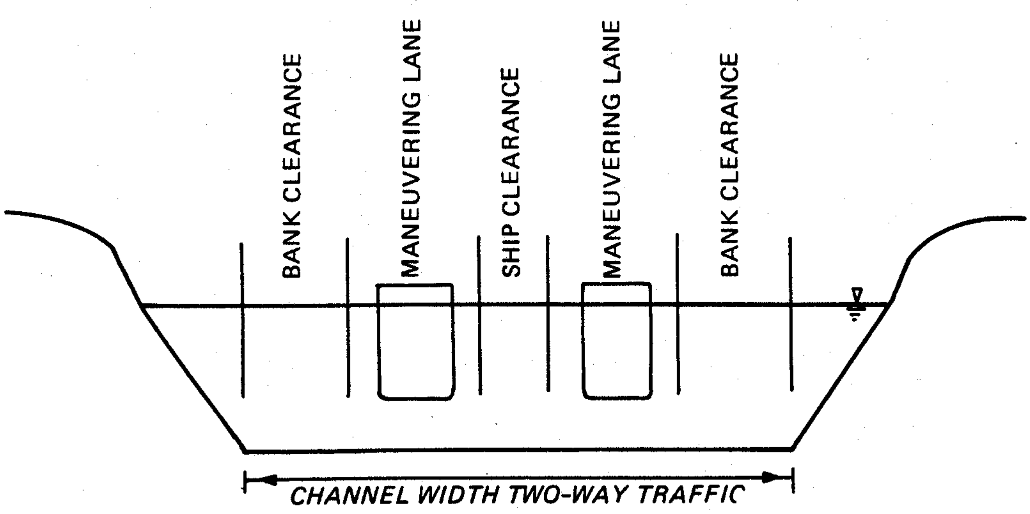
g. Project Maintenance. In estuaries and lakes, channel dimensions are normally maintained by dredging, although training structures such as rock jetties are also commonly used to exclude littoral drift sediments from harbor entrances and to stabilize the channel location. In rivers, channel dimensions are also maintained by dredging, but training works such as pile dikes (Lower Columbia) or articulated concrete mattresses (Lower Mississippi) may be helpful as well.

h. Ship-Generated Waves. Moving ships generate waves that can pose a hazard to pleasure craft, cause bank erosion, and affect the stability of shoreline structures. The effects of waves will depend on the height of the generated wave and the distance between the ship and the smaller boats or shoreline. Mitigation measures may be required if ship waves are higher than those naturally occurring from wind or ocean swell or those created by pleasure craft. The two most common mitigation measures are reduced speeds and shore protection. In some cases, it may be practical to locate the navigation channel a sufficient distance from the shore so that the waves reaching the shore will not be destructive.

i. Miscellaneous. Other items that require engineering study include turning basins, jetties, control or training structures, shore protection, entrance channels, obstructions such as bridge piers, and aids to navigation.



a. One-way traffic



b. Two-way traffic

Figure 2-3. Channel width elements

2-3. Water Quality Considerations.

a. General. Water quality considerations for addressing potential impacts of deep-draft navigation projects can be categorized as follows:

(1) Dredging and disposal during construction and maintenance.

(2) Increased pollutant loadings due to facility construction, vessel discharges, and accidental spills.

(3) Altered or absence of circulation due to changes in geometry.

(4) Salinity changes.

Industrial and municipal effluents and agricultural runoff with attendant problems of low dissolved oxygen (DO), eutrophication, or toxic contamination are not a primary Corps concern unless Corps activities have the potential to mitigate or intensify already existing water quality problems. However, these conditions and the potential for water quality problems should be identified and documented in the early project stages.

b. Dredging and Disposal. In general, adverse water quality impacts directly attributable to the release of chemical substances into the water column by dredging activities are minimal. Procedures are available for evaluating the environmental impacts of the three major disposal alternatives: open-water, intertidal, and upland methods (see paragraphs 3-5 and 4-1). Water quality considerations for dredging and disposal operations are summarized in the DMRP Synthesis Report Series. An index of these related reports is given in WES TR DS-78-23 (Herner and Company 1980). For detailed information on water quality considerations during dredging, refer to EM 1110-2-5025.

c. Pollutant Loadings. Deep-draft navigation projects can stimulate the construction of associated anchorage, loading, storage, and related facilities. Associated with industrial development are possible industrial effluents, spills, and surface runoff contamination. Increased waterborne traffic increases the possibility of vessel discharges and accidental spills.

d. Altered Circulation.

(1) Circulation may be altered as a result of changes in channel geometry and bottom topography caused by dredging and dredged material disposal. Changes in circulation may result in changes in the spatial distribution of water quality constituents, changes in the flushing rates of contaminants, and changes in the pattern of scour and deposition of sediments.

(2) Environmental assessment of the effects of changes in circulation should initially emphasize the physical parameters such as salinity, temperature, and velocity and their impacts on plant and animal communities. These initial analyses should consider changes in vertical stratification when deepening of a channel is proposed. Increased density stratification inhibits vertical mixing, which may result in depletion of DO in bottom waters. If minimal changes occur in these parameters, then it can be generally assumed that the chemical characteristics of the system will not change significantly. This

approach is based on a methodology that permits assessment without requiring extensive data and knowledge of the processes affecting the water quality constituent of direct interest. However, this approach is invalid if preliminary water quality surveys indicate the existence of toxic constituents at concentrations potentially damaging to biotic populations. Prediction of change in circulation and its effect on the physical parameters can be achieved through comparison with existing projects, physical model studies, and numerical simulation. Additional information on water quality considerations is provided in paragraph 5-2.

2-4. Biological Considerations.

a. General. The effects of deep-draft waterways on plants and animals result from physical changes in habitat due to the enlargement of channels, disposal of dredged material; and construction of associated locks and dams, revetments, breakwaters, jetties, and navigation aids. Other effects may result from changes in contaminant levels, turbidity, suspended sediments, salinity, circulation, and erosion. Preliminary research suggests that navigation traffic itself affects certain species.

b. Physical Change in Habitat. Short- and long-term habitat effects may result from deep-draft waterway construction activities.

(1) Short-term effects include the burial and disturbance of the organisms in the vicinity of the activity. Fish, birds, and other mobile organisms can leave the area while less mobile biota, such as benthic invertebrates and rooted plants, are buried. Since many aquatic organisms recolonize rapidly, the primary concern for short-term effects is the loss of environmentally sensitive species, coral reef species, and commercially or recreationally important species such as clams, oysters, and mussels. In addition, long-lived species such as mussels may be slow to recover from a physical impact and may require additional consideration in the impact study. When endangered or threatened species are present, the Corps must implement Section 7 of the Endangered Species Act.

(2) Long-term effects are changes in habitats, including changes in depth, substrate particle size (e.g. sand to mud, or sand to rock structure), chemical constituents (e.g. nutrients and contaminants), and flows (e.g. direction and magnitude of current). Along with these changes, an associated change in organisms that use these habitats also occurs. The more mobile organisms may relocate to other areas if the affected areas become unsuitable. The more sedentary organisms, such as marine worms, clams, and other benthic invertebrates, may either recolonize the habitat or, if changed, be replaced by organisms suited to the new habitat. Some of the habitats are finite and their loss would be a major concern. Such habitats may include spawning areas for fish, coral reefs, oyster reefs, wetlands, or feeding areas for birds. Another consequence can be increased species diversity from increased habitat diversity. The area must also be evaluated in the early project stages to determine if it has been designated as critical habitat for endangered species.

(3) Secondary effects such as a change in benthic species size or depth occupied below the sediment surface may change their suitability or availability as food to predators.

c. Contaminants. Changes in contaminant levels may be caused by dredging activities, construction activities, vessel discharges and spills, prop wash, and circulation pattern alterations. Contaminants pose a potential hazard to aquatic life. They may cause mortality or chronic effects if the contaminants, when persistent and present in a bioavailable form, are taken up by organisms. This may be particularly significant if highly contaminated areas are to be disturbed by the project activities.

d. Turbidity/Suspended Solids. Activities that can be responsible for generating increased turbidity and suspended solids are vessel movements, prop wash, change in circulation, erosion, and dredging and disposal of dredged material.

(1) Resuspension of bottom sediment in the wake of large ships, tugboats, and tows can be considerable. For example, each year shrimp trawlers in Corpus Christi Bay, Texas, suspended 16 to 131 times the amount of sediment that is dredged annually from the main ship channel. In addition, suspended solids levels of 0.1 to 0.5 parts per thousand (ppt) generated behind the trawlers are comparable to those levels measured in the turbidity plumes around open-water pipeline disposal operations. In fact, where bottom clearance is 3 feet or less, a scour depth of up to 3 feet may occur in easily suspended sediments.

(2) Research results from the DMRP indicate that the traditional fears of water quality degradation resulting from the resuspension of dredged material during dredging and disposal operations are for the most part unfounded. The possible impact of depressed levels of DO has also been of some concern, due to the very high oxygen demand associated with fine-grained dredged material slurry. However, even at open-water pipeline disposal operations where the DO decrease should theoretically be greatest, near-surface DO levels of 8 to 9 parts per million (ppm) will be depressed during the operation by only 2 to 3 ppm at distances of 75 to 150 feet from the discharge point. The degree of oxygen depletion generally increases with depth and increasing concentration of total suspended solids; near-bottom levels may be less than 2 ppm. However, DO levels usually increase with increasing distance from the discharge point, due to dilution and settling of the suspended material.

(3) It has been demonstrated that elevated suspended solids concentrations are generally confined to the immediate vicinity of the dredge and discharge point, and dissipate rapidly at the completion of the operation. If turbidity is used as a basis for evaluating the environmental impact of a dredging or disposal operation, it is essential that the predicted turbidity levels be evaluated in light of background conditions. Average turbidity levels as well as the occasional relatively high levels that are often associated with naturally occurring storms, high wave conditions, and floods should be considered.

(4) Fluid mud (or fluff) is a special case involving high concentrations of suspended sediments. It can occur during open-water disposal of hydraulically dredged, fine-grained material having a high water content. Fluid mud creates a layer of low DO and unstable substrate for bottom-dwelling organisms.

(5) Clam or oyster beds, coral reefs, highly productive areas, and other sensitive habitats have the potential for the greatest effect from turbidity and suspended solids. The presence of these areas in the project area should be determined, and special turbidity control measures should be used to protect these areas from the impacts of project activities (refer to WES TR DS-78-13).

(6) Potential impacts of elevated suspended sediment concentrations on egg and larval stages of fishes have been identified as a primary concern by resource management agencies. Egg and larval forms, due to their essential dependence on local hydrodynamic conditions for transport into and out of project areas and their limited or lacking avoidance capabilities, are considered to be more susceptible to detrimental effects than motile juvenile and adult life history stages (Lunz et al. 1984a,b). Two basic reproductive patterns by fishes generate different types of concern in relation to dredging operations. Many estuarine-dependent species produce pelagic (free floating, unattached) eggs which, depending on their densities, may occur at various levels in the water column from surface to bottom. Potential impacts on pelagic eggs are therefore related to both spatial distributions of suspended sediments and duration of exposure at specific concentrations. Other fish species produce demersal, nonbuoyant eggs which may adhere to substrate and remain in place for short to extended periods of time prior to larval hatching and release. In addition to the problem of exposure duration, demersal eggs may be subject to burial by accumulated deposited sediments. The actual causal factors by which suspended sediments affect eggs and larval fishes are complex and little understood. Some of these factors are mechanical abrasion of egg and larval surficial membranes, reduction of available light in the water column, and sorption of contaminants carried by the sediments. Very little is known of the importance, if any, of synergistic effects resulting from combinations of causal factors, or of physical features of the suspended particles such as size or angularity. Stresses of chemical, physical, or biological nature may be manifested in chronic rather than acute effects. Indirect effects of elevated suspended sediments may be of consequence, for example through interference with feeding behavior of visually oriented larvae, or delayed development resulting in asynchronous occurrences of larvae and their prey. There is some indication that larval stages are more sensitive than egg stages. In light of current knowledge of spatial extent of suspended sediment concentrations associated with dredging operations, and in consideration of expected durations of exposure of eggs and larvae in project areas, there is no evidence that dredging operations (assuming no contaminants are present) adversely impact fish egg or larval stages with the exception of the occurrence of demersal eggs within 500 yards of the dredge location.

(7) In contrast to the data for fish eggs and larvae, data for oyster eggs and larvae showed greater effects to natural sediment suspensions (Lunz et al. 1984a, b). Special consideration should therefore be given to proximity of productive oyster reef or other shellfish beds to proposed dredging operations. Designation of a "buffer zone" should take into account individual site characteristics such as currents and circulation, as well as material composition and other characteristics.

(8) Insofar as direct physical effects of elevated suspended sediment concentrations on juvenile fish stages are concerned, the literature is sparse and incomplete (Lunz et al. 1984a, b). Insufficient evidence is

available which to base assertions that dredging operations involving uncontaminated sediments pose either real or insignificant physical threats to juvenile fishes or shellfishes. Consideration should therefore be given to both scale and location of proposed dredging operations on a case-by-case basis, but restrictions based solely on seasonal concerns alone appear justified.

(9) Some additional concern is warranted with regard to sessile forms to estuarine and coastal invertebrates (Lunz et al. 1984a, b). Sessile or other forms having very limited powers of locomotion can be assumed to be susceptible to long-term exposures of elevated suspended sediment concentrations in the immediate vicinity of dredging operations. Most shellfishes adapted to naturally turbid estuarine conditions have adequate mechanisms, exemplified by valve closure or reduced pumping activity or oysters, to compensate for short-term exposures. There is insufficient technical information upon which to establish conclusive relationships between dredging-related turbidity fields and significant impacts on adult and subadult shellfishes. "Buffer zones" around operating dredges should be determined on a case-by-case basis, taking into account the resources at the site, as well as site and material characteristics.

(10) There are two fundamental areas of concern related to subadult and adult fish: (a) elevated concentrations of suspended sediments have detrimental effects on adult and subadult fishes; and (b) turbidity fields constitute a barrier to migratory patterns of sensitive species, especially anadromous salmonids, herrings, striped bass, and others (Lunz et al. 1984a, b). The latter concern is by far the more difficult to address. The supposition that a given species will not cross or circumvent a turbidity field can be substantiated or refuted only by properly designed field studies. There is no known existing data which conclusively demonstrate behavorial responses of a negative positive, or indifferent nature on the part of target species to the presence of turbidity field or plumes. However, significant evidence supports the fact that adult and subadult stages are moderately to extremely tolerant of elevated suspended sediment concentrations. Given that the level of suspended sediment surrounding a dredging activity seldom exceeds 1,000 milligrams per liter, and this level is confined to a relatively small areal extent, there is no justification to predict significant dredge-induced physical effects on adult estuarine fishes. Additionally, there is no justification to suspect that these highly mobile organisms would be subjected to dredge-produced elevated suspended sediment levels for sufficient periods of time to incur even sublethal adverse effects. Possible exceptions include dredging operations handling contaminated sediments, or sediments consisting primarily of highly angular particles that could abrade the fishes' gills or other sensitive membranes.

e. Salinity. Changes in salinity may result from changes in circulation patterns resulting from channel enlargement, structures, and navigation traffic.

(1) Salinity has a major effect on specific composition, especially on lower food web components, including microalgae, emergent vegetation, plankton, and bottom-dwelling organisms. Salinity also determines fish distributions. As it affects flood distribution (prey), it also affects bird and fish feeding locations.

(2) The effect of a change in salinity on a given organism is dependent on its sensitivity to saline water. Juvenile marine fish are often more tolerant of lower salinities and generally are found in the shallow, less saline bays or further upriver, while adults of these species may be confined to deeper channels or may not enter the estuary. Free-moving animals such as fish can adjust their movements to the change in salinity, which may in turn change utilization of feeding, resting, and spawning habitats. Nonmobile organisms sensitive to the change will be replaced by biota more tolerant of the new salinity. Again, this is dependent on the magnitude and rate of the salinity change with reference to a species tolerance range and will generally be determined by tidal and seasonal minimum salinity.

f. Circulation. Channel deepening and navigation structures may change circulation and flushing conditions, which influence movement patterns of floating and free-swimming plants and animals within rivers, lakes, estuaries, and embayments and between coastal bodies of water and the ocean. These movement patterns influence their availability as food to other organisms, utilization of food and spawning areas, and their occupation of a habitat. The movement of sediment, turbid water, fresh water, saltwater, nutrients, and contaminants may be altered by changes in circulation, and in turn may affect the organisms present in the impacted area.

g. Erosion. A change in the rate of erosion may result from channel enlargement, circulation pattern alterations, and navigation traffic increases. Deepening and widening the channel may increase the instability of the channel. An increase in size and number of boats may increase erosion by the prop wash and of shorelines from wave wash. Alteration of water circulation patterns will cause some areas to become depositional while others become erosive.

(1) The stability of a bottom or shoreline has a major effect on the organisms present. Highly erosive areas generally have fewer numbers and species (Figure 2-4). The species will change to those adapted to the unstable conditions.

(2) Many other erosive forces may mask or confound the effects of project-associated erosion (for example, wind- versus vessel-induced waves).

h. Navigation Traffic. The impacts of navigation traffic on biota have been debated for a number of years; however, at present there is a scarcity of documentation concerning actual observed biological impacts resulting from navigation traffic. Ship passage can cause the suspension of some bottom-dwelling macroinvertebrates. Resuspension of sediments by navigation traffic is also of concern since (Figure 2-5): (1) increased suspended solids result in decreased primary productivity; (2) ships may resuspend and redistribute sediment particles, transporting them in a lateral direction, resulting in increased deposition in shallow waters, backwaters, and secondary channels; and (3) increased sedimentation might result in the "smothering" of benthic organisms and destruction of fish spawning areas, oyster beds and coral reefs. Of the various possible biological impacts from navigation traffic, one having the greatest potential impact would be wave and drawdown disturbance on littoral (shoreline) shallow water and/or backwater areas. Such habitats are important since they serve as nursery areas for larval and young-of-the-year fish and support highly productive macroinvertebrate and plankton communities.

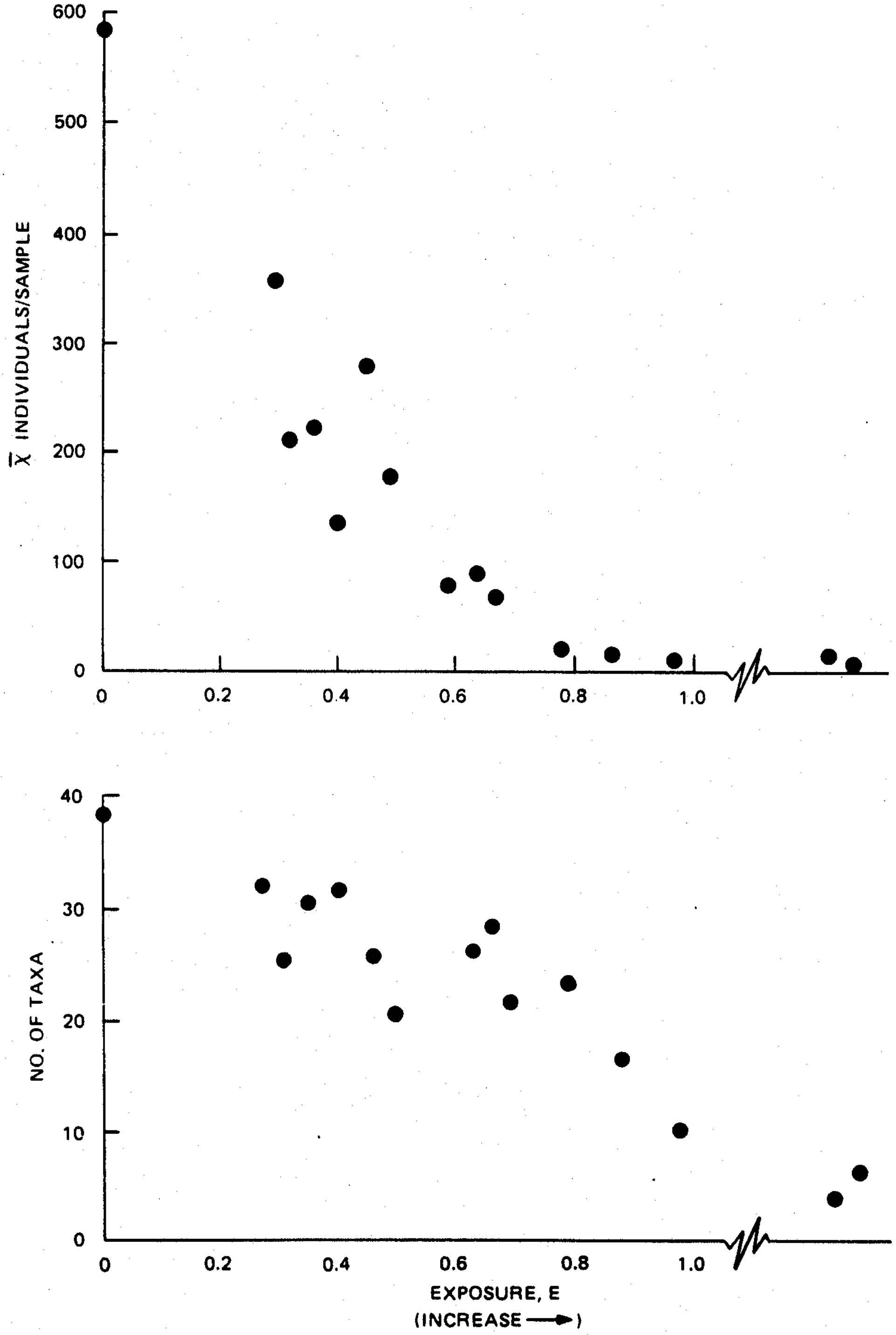
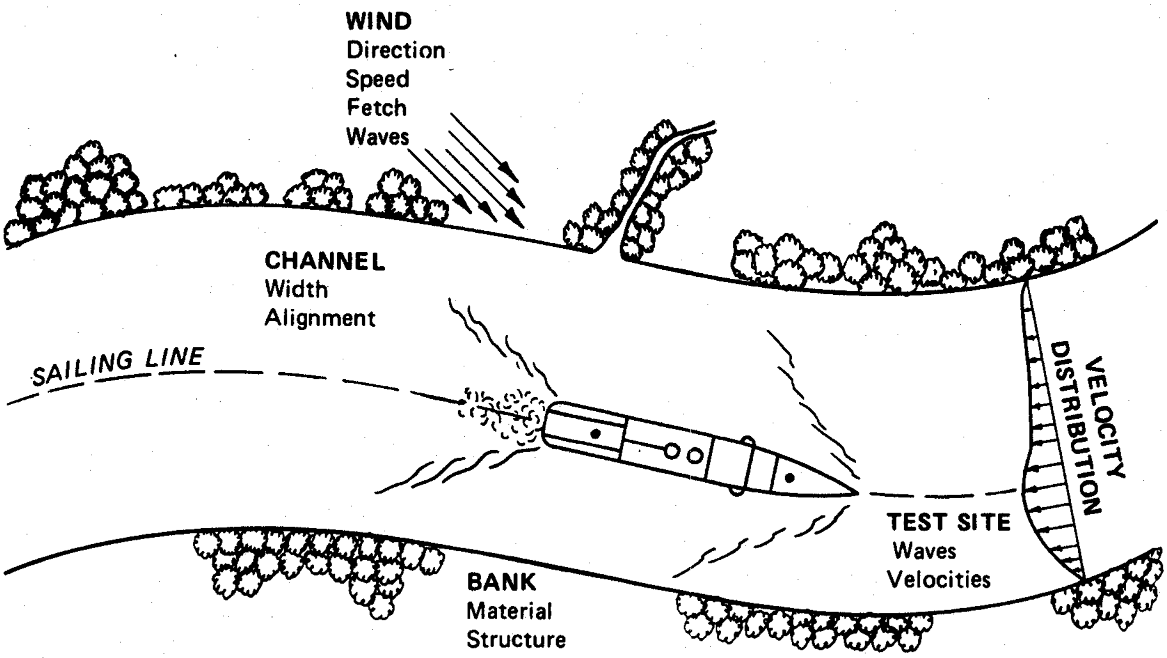


Figure 2-4. Relationship between exposure to wave action and total benthos and number of taxa, $E = \log(1 + fwd^{-2})$, where f = fetch, w = fraction of time wind blew toward station, and d = depth of station



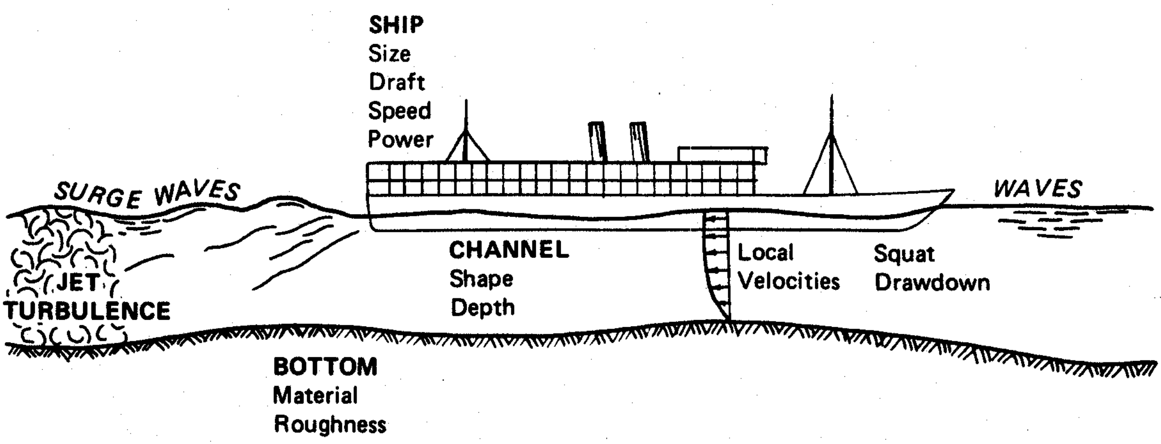


Figure 2-5. Physical effects of navigation

2-5. Recreational Considerations.

a. Basic Requirements. Recreation development requires cost sharings by a local sponsor. Refer to ERs 1165-2-400 and 1105-2-20 for cost sharing policies. Additional basic requirements for recreation developments include:

(1) Sufficient demand to ensure utilization of the facility.

(2) Publicly controlled sites, including access routes.

(3) Justified provisions for prevention of vandalism.

b. Selection of Features. Refer to ER 1105-2-20 and Appendix D of ER 1120-2-400 for a description of the types of recreation facilities eligible for Federal cost sharing. In general, eligible facilities are those not ordinarily provided by private enterprise or on a commercial or self-liquidating basis. In addition to these regulations, feature selection is also controlled by project site characteristics.

(1) Structures. The recreational potential of engineering structures such as bridges and piers is generally limited, although in some cases slight modification of structures may increase their suitability. For example, jetties often provide additional fish habitat and may become popular fishing spots. Provision for access, parking, and public safety can enhance recreational potential. Modifications can be incorporated during the design stage or retrofitted to existing structures.

(2) Lands. Project lands, whether purchased or created through dredged material disposal or accretion, have high and diverse recreation potential. They are especially attractive for shoreline recreation development such as swimming beaches, boat launching ramps, marinas, and fishing piers. When areas are of sufficient size, campgrounds (Figure 2-6), multiple play areas, and trail systems are appropriate. While high-intensity recreational use is generally dependent on facilities development, undeveloped project lands can support activities such as nature study, hunting, and beachcombing if sufficient access is provided. Table 2-2 outlines specific activities and required facilities for recreational use of deep-draft navigation areas.

c. Design of Recreation Features. Refer to ER 1110-2-400 for guidance on design of recreation features. Additional information regarding land-based recreation and water-based activities suitable for riverine settings is given by Hynson et al. (1983) and Nunnally and Shields (1983).

d. Carrying Capacity. Recreation facilities should be sized and located to avoid overutilization or underutilization. as well as conflicts with other uses such as navigation. Refer to WES IR R-80-1 (reference 43) for methods to estimate carrying capacity. Overuse often results in degradation of the recreational resource.

2.6. Aesthetics.

a. General. Deep-draft navigation projects affect aesthetic characteristics of the environment through changes caused by construction and

Figure 2-6. Shoreline camping area

Table 2-2. Recreational Activities and Facilities, Deep-Draft Navigation Areas

Activities	Facilities
Beachcombing	Beach
Bicycling	Trail or road
Boat launching	Ramp, parking area
Camping	Campground
Fishing	Water access
Hiking	Trail
Hunting	Sufficient area and habitat
Nature study	Natural area
Outdoor games	Multiple play area
Picnicking	Tables, trash receptacles, fireplaces
Sunbathing	Beach
Swimming	Suitable water and shoreline
Sightseeing	Scenic overlook or viewing tower

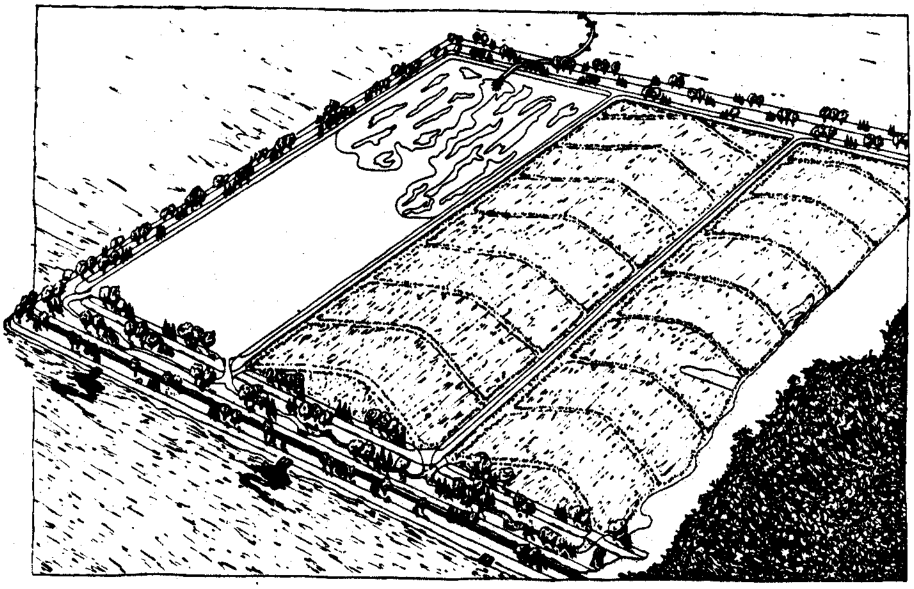
maintenance activities and by the presence of navigation traffic. The aesthetic value of an environment is determined by the combination of perceptual stimuli inherent in the environment, i.e., the sights, scents, tastes, and sounds and the interaction of these. Visual changes are the major aesthetic effects of deep-draft navigation projects. The visual environment for deep-draft navigation includes terrestrial landscapes, shorelines, open-water channels, and waterways. Relatively remote coastal areas associated with some deep-draft navigation projects offer a high-value aesthetic experience for recreators or others present in the project area.

b. Aesthetic Design. All landscape components possess visual properties such as color, form, line, texture, scale, and spatial character. Color refers to an object's light-reflecting properties; line, to the path followed by the eye when viewing an object (usually evident as the edge or outline of an object); texture, to the aggregation of small forms or color mixtures into a larger pattern; scale, to the proportionate size relationship between an object and its environment; and spatial character, to the object's placement or arrangement in three-dimensional space. All of these properties can be manipulated, to some extent, in project design to increase positive visual effects. Scale may be constrained more than the other properties, however, because of its dependence on object size and the limitations on choice of size for most project features. Examples include the use of natural materials which possess colors, forms, and textures that are more desirable than man-made materials, topographic modification of monotonous landscapes by grading or placement of dredged material, and selection and placement of trees and shrubs to improve color, form, line, texture, and scale (Figure 2-7). Landscape design guidance for confined upland dredged material disposal areas and other large structures is provided in Mann et al. (1975).

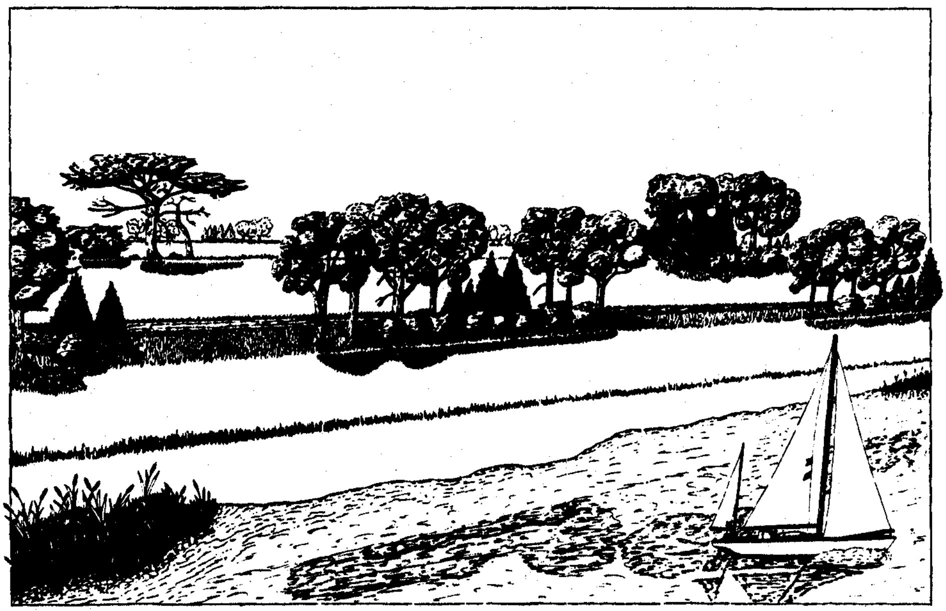
c. Visual Contrast Rating (VCR) System. Potential visual impacts of proposed waterway projects or impacts at sites of existing projects can be assessed with a procedure such as the VCR system used by the Bureau of Land Management. Sheppard and Newman (1979) provide detailed instructions for application of a modified version of the VCR process. The evaluation procedure involves use of drawings or photographs of the site landscape with modifications artistically superimposed. Assistance of a landscape architect may be required for preparing these scene simulations. Because of the highly personal nature of reactions to visual stimuli, several independent evaluations may be required to generate reliable results for complex projects, and the assistance of a qualified person experienced in visual impact assessment is recommended. Additional methodologies are reviewed in a special issue of the Coastal Zone Management Journal (1982).

2-7. Cultural Resources.

a. General. Federal statutes require identification and protection of significant cultural resources in the project area. Cultural resources are the physical evidence of past and present habitation that can be used to reconstruct or preserve human activity. This evidence consists of structures, sites, artifacts, and objects that may be studied to obtain relevant information (Figure 2-8). Cultural resources found in deep-draft navigation project areas provide physical evidence of how the areas were used for commercial and game fishing, navigation, agriculture, and other activities during historic and



a. Artist's conception of overall appearance of disposal area, showing alteration of disposal operations, interior trenching, and landscaped dikes



b. Artist's conception of exterior of landscaped dikes from the water level

Figure 2-7. Use of landscaping to modify visual properties of a large diked dredged material disposal area

Figure 2-8. Historically significant vessel

prehistoric periods. Identification and interpretation of cultural resources sites clarify the relationship between present-day use and past use. This information about cultural resources is used in the design phase to ensure that proposed designs will preserve and protect identified cultural resources. For example, disposal areas may be located some distance from the identified sites. This concern for cultural and archaeological resources needs to be pursued during the construction stage. It requires monitoring the dredging and disposal operation and any excavation by observers skilled in archaeological find identification.

b. Cultural Resources Analysis. An analysis of the cultural resources of the project area is usually done during the planning phase to identify sites that require mitigation (which may include preservation measures) due to their cultural significance. An analysis of cultural resources includes an inventory of the cultural resource sites and an assessment of the potential losses or damages due to the project. All activities should be coordinated with the State Historic Preservation Officer (SHPO). Identification of sites is accomplished through interviews with local officials and residents and by examination of archival materials such as the National Register of Historic Places, National Architectural and Engineering Records, maps, and official records. The interviews and archival search delineate the density of sites and the types of sites present, i.e., prehistoric sites, historic sites, architectural elements, and engineering elements. Cultural resources can also be identified through magnetometer surveys of underwater areas, and from ground surveys of candidate upland disposal sites. The significance of each site is determined based on regional characteristics and professional judgment. Identification and evaluation of a site may require site visits or excavation to verify information. Loss or damage to sites from preliminary or potential project designs can be determined from the inventory and significance analysis.

c. Cultural Resources and Design. Project designers should use the cultural resources analysis to develop designs that incorporate protection of the resources. The protection measures incorporated in designs should be determined based on characteristics of the resource, the project area, and operational and maintenance activities. Cultural sites affected by waves may be stabilized by vegetation or riprap. Physical resources may be excavated and stored. Resources that will be inundated or covered with dredged material or sediment can be removed from the site or stabilized and protected prior to construction, so as to be recoverable later.

2-8. Winter Navigation.

a. General. When ice covers a waterway a number of additional environmental considerations come into play. How these are changed by project development and navigation must be addressed in the EIS. Project development can alter ice growth patterns by causing ice to form in new areas and, conversely, causing areas previously covered by ice to remain open. Navigation breaks up the ice allowing it to move; this presents additional problems.

b. Ice Cover Effects. The existence of an ice cover will change the water quality by reducing wave-induced turbidity and hindering gas exchange with the atmosphere. People and animals use the ice cover as a bridge. Many bird species move south when their aquatic food supply is no longer available. The ice cover is used for such recreational activities as snowmobiling, skating, and ice fishing.

c. Navigation Effects. Navigation through an ice cover obviously breaks it up, thereby reducing its value for recreation. But there are many other effects which should be considered. To break and push aside the ice requires higher ship thrust, which results in greater propeller-induced scour. Water drawdown and surge effects along the shoreline are more noticeable. The drawdown can ground the ice. The repeated breaking and churning of the ice accelerates its growth so the ice becomes thicker along the vessel track. One result is a greater blockage of the channel cross section, which in turn alters current directions and speed.

d. Ice Control Measures. There are a number of ice control measures which will mitigate the effects mentioned above. A review of EM 1110-2-1612 will cover these in detail. For example, air bubblers and air screens can minimize ice growth and direct ice movement, respectively. Ice booms (Figure 2-9) and man-made islands can be used to hold ice in place and yet allow vessel passage.

Figure 2-9. Ore carrier downstream of ice boom on St. Marys River at outlet of Sault Ste. Marie Harbor. An ice boom is located about one ship length astern